Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

1.9
P772Ht

H.T. + S. Office report
no. 114

LIBRARY
CURRENT SERIAL RECORD
JUN 25 1943
U. S. DEPARTMENT OF AGRICULTURE

~~DENTIAL~~

REPORT ON EXPERIMENTAL WORK DEALING WITH THE
PRECOOLING
TRANSIT REFRIGERATION
RIPENING
OF CALIFORNIA BARTLETT PEARS DURING THE
1942 SEASON

(A cooperative investigation by the Bureau of Plant Industry, U. S. Department of Agriculture; the Division of Pomology, California Agricultural Experiment Station; and the California Tree Fruit Agreement.)

By

W. T. Pentzer, physiologist, C. O. Bratley, pathologist, A. Lloyd Ryall, associate pomologist, and James S. Wiant, associate pathologist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Soils and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture.

F. W. Allen, associate pomologist and H. T. Hartmann, research assistant, Division of Pomology, California Agricultural Experiment Station.

C. N. McClanahan and Warren G. Tufts, California Tree Fruit Agreement.

INTRODUCTION

The 1941 studies on shipping and ripening Bartlett pears showed that the most serious cause of complaint with this fruit, a type of breakdown that developed on the fruit stands, could be prevented by using cool ripening temperatures of about 65°F. instead of allowing the pears to ripen under high temperatures such as frequently exist in the retail markets. The Bartlett Pear Commodity Committee recommended the continuation of these studies to see whether fruit grown in 1942 would behave similarly in this respect and whether the findings on other phases of pear shipping would bear out those obtained in 1941.

METHODS

The methods followed were the same as those of the previous season. Test boxes of pears were loaded in commercial shipments for inspection upon arrival and for observation when ripened at 67° and at 83°F., the latter temperature representing fruit-store conditions during warm weather, and the former temperature representing a good ripening temperature for pears. Ripening tests were also made at Davis in which temperatures of about 65° and 85° were compared. Periodical inspections were made of commercial shipments on the retail and wholesale markets and color photographs were sometimes taken to show the condition of pears as they were unloaded from the car and after they were ripened.

Boxes of fruit in the shipping tests were placed in the top layer of the doorway stack, a position in the load that is likely to be one of the warmest in transit. In some non-precooled cars, test fruit was also loaded in a cool position, the bottom layer of the bunker stack. Recording thermometers were packed in the center of the boxes to give temperature records from the time the fruit was loaded into the car until it was unloaded in the eastern market, a period referred to in the report as the "transit period", although it encompassed the time spent in precooling as well as the actual transit period. The temperatures of pears during precooling were taken at various positions in the load by means of distant-reading electric-resistance thermometers read from outside the car.

Since no difference was found between shipping districts in 1941 in the response of fruit to high-temperature ripening, the work in 1942 was confined for the most part to the Sacramento Valley. In addition to the precooling and transit temperature studies, the tests were expanded to compare acid-washed and unwashed pears in respect to their susceptibility to breakdown when ripened at temperatures favoring its development. Samples of these lots were also held at Davis, California, to observe any effects from acid washing.

The main points covered in the 1942 tests were the following:

1. What temperatures are needed in precooling and in transit to prevent excessive ripening and still not result in too green fruit on arrival?

2. Do transit temperatures affect flavor or the amount of breakdown that develops?

3. The susceptibility of Bartlett pears grown in 1942 to breakdown and its control by ripening temperatures of 65° to 67°F.

4. The minimum ripening period needed at 65° to 67° to insure good quality.

5. Do pears that have been washed in cold or warm solutions of hydrochloric acid develop any more breakdown than unwashed fruit?

Test shipments were made in 13 cars of pears in 1942 (table 1) that received different amounts of refrigeration. Some were not precooled and others were precooled until the pears were close to 33°F. throughout the boxes. The transit refrigeration in some cases consisted of initial ice only, while other cars were iced 10 to 12 times enroute (standard refrigeration). Test shipments were begun July 15 with the first car of Bartletts that was shipped from California in 1942. The season was one of the latest on record chiefly because the pears were slow to size and the industry made an effort to postpone shipments until the fruit had sufficient size and was mature enough to give satisfaction. The normal ripening and good flavor of the early shipments this season in contrast to the poor showing made in some years can be credited to the delay in time of harvest.

RESULTS

Appearance and condition of fruit upon arrival.

The appearance of the pears and their condition on arrival in respect to the way they were refrigerated and the temperature to which they were exposed are discussed in this section of the report. As was mentioned above, the tests were carried on in the warm part of the load unless noted otherwise and the results are therefore indicative of what took place here rather than in the remainder of the load. This was done because it was believed that if the top layer could be refrigerated adequately the condition of the rest of the load would be assured and conversely, if the top layer was too green, fruit in the cooler portions of the load would be even less attractive.

To simplify the discussion, the average of the transit temperatures has been used for comparisons. In this comparison the time required to cool the pears to temperatures that were low enough to check ripening should also be considered.

Test 1, Walnut Grove, California, July 15. Non-precooled 720-box, through load, shipped standard refrigeration.

The pears in this car were 73°F. shortly after they were loaded and they cooled slowly in transit, reaching 65° in 2 days, 57° in 4 days, 50° in 6 days and arrived with a temperature of 48° on the 11th day (figure 1). The average temperature for the transit period was 56°. The fruit softened 14 pounds under these high transit temperatures, from an initial pressure test of 21 pounds to a final one on arrival of 7 pounds. For early shipments that move into consumption immediately, the pears were considered to be in excellent condition for the auction and only slightly on the ripe side (table 2). If the weather had been warm when this shipment was made, as it was during the following week, some precooling would have been needed to prevent excessive ripening in transit.

Test 2, Yuba City, California, July 20. Non-precooled load, reiced twice in transit.

The fruit in test 2 was about 76°F. when loaded and it cooled even more slowly than in car 1, reaching 68° in 2 days, 63° in 4 days, 58° in 6 days, and arriving with a temperature of 52° (figure 1). The average temperature for the transit period was 62°, but despite this the pears were considered to be in excellent condition for the auction when they were unloaded. They softened approximately

12 pounds, having a pressure test of 8 pounds when they arrived (table 2). In the cool part of the load, bottom layer of the bunker stack, where the temperature averaged 45 , the fruit softened very little and was considered to be slightly green for best auction display. The commercial shipment of fruit in this car as it was displayed on the pier was in perfect stage of ripeness for the auction, for the color was beginning to break and the fruit was firm.

Tests 3 and 4, Courtland, California, July 25 and 26.

These tests consisted of two cars, one with a 550-box load, non-precooled, shipped under standard refrigeration (car 3), and the other with a 720-box load, precooled for 21½ hours to a final temperature of 44°F. The latter was shipped with 2 reicings in transit. As was the case in last year's tests when two such cars were compared, the non-precooled light load had a higher transit temperature than did the heavy precooled load (figure 2). The average temperature (top layer, doorway stack) for the transit period was 54° for the non-precooled car and 49° for the precooled car. One day was lost in precooling car 4 and it was delayed further in transit resulting in a 12 day transit period as compared to 10 days for car 3. Upon arrival, one lot of fruit was slightly green in car 3 and the other lot was in excellent condition as were both lots in car 4. The commercial displays from both cars were in an excellent stage of ripeness.

The fruit from the bottom layer of test car 3, where it had an average transit temperature of about 45°, was slightly too green upon arrival, agreeing with the results of test 2 where a similar temperature held back coloring too much in transit.

It is apparent from these four early shipments that average transit temperatures of 49°, 54°, and 56° were satisfactory and that the non-precooled loads carried through in good condition. If the weather had been extremely warm, as it was between July 20 and 25, precooling would have been advisable in all of these cars for temperatures would have been high enough to cause too much ripening in transit. Although fruit in car 2, which had 62° average transit temperature, arrived in good condition, it is believed that such temperatures are too high as a general rule for the safe transportation of Bartlett pears.

Test 5, Locke, California, July 30.

720-box solid load, precooled to 45 F., shipped under standard refrigeration, 3 percent salt at the first icing.

The temperatures in car 5 showed the effect of good precooling. The top layer, doorway was 32° when precooling was finished but other portions of the load were not this cool, for the average of 9 positions was 45°. Because of this, and subsequent heat leakage into the car, the top layer warmed to 45° in 5 days and was held at 46° for the next 2 days until the test boxes were removed from the car at Buffalo for shipment by express to New York City (figure 3). The average temperature for the transit period was 50°, including the 2 days enroute from Buffalo to New York without refrigeration. All but one of the 4 lots shipped in this car arrived slightly ripe for the auction (table 2). This can be attributed to the high temperatures to which the fruit was exposed after removal from the car, for the refrigeration the car received was adequate.

Tests 6 and 7, Yuba City, California, July 29.

Car 6 precooled to 44°F. car 7 precooled to 55°, both reiced twice in transit.

This test was made to see if precooling for a short time, about 8 hours, was enough for midseason shipments of Bartlett pears that were fully as firm as fruit shipped 10 days earlier at the start of the season. The transit temperatures obtained in this car (car 7) and in a companion car (car 6) which was precooled for 18½ hours, are shown in figure 3. The average transit temperatures of the two shipments (top layer, doorway stack) were 50° for car 6 and 54° for car 7. Although both lots of test fruit arrived in an excellent condition for the auction, there were a few pears riper than desirable in the car with the short precooling, indicating that the longer cooling was to be preferred, for it gave some margin of safety and at the same time did not check coloring too much.

Test 8, Courtland, California, August 7. 720-box, braced load, precooled to 39°F., shipped under standard refrigeration.

This well-cooled car had an unusually low transit temperature of close to 40° for most of the trip (figure 4), averaging 42° for the entire period. No comments were made when this car was inspected concerning the condition of the fruit on arrival in respect to auction preference, but its color and firmness indicated that it was in excellent condition for the wholesale trade. The fruit was fairly mature at time of shipment, testing 18.1 pounds (table 2) consequently it needed the good refrigeration it received.

Test 9, Placerville, California, August 8. Non-precooled, standard refrigeration.

A comparison of washed and unwashed fruit was made in this test and is discussed elsewhere in the report. The transit temperature of the car, as compared with that of well-cooled car 8, is shown in figure 4.

Tests 10 and 11, Yuba City, California, August 12. 608-box, braced load, car 10 precooled for 42 hours to 39°F., car 11 precooled for 14 hours to 51°, each car shipped with 2 reicings in transit.

The longer precooling that car 10 received had a marked effect in lowering the transit temperature of the top layer, doorway stack (figure 5) for it had an average temperature for the trip of 41° as compared to 52° in car 11. The fruit shipped in these cars was mature, testing 17.8 pounds with 2-plus color. Both shipments were delayed in transit and they were also held on track for several days before they were unloaded, resulting in transit periods of 14 days for car 11 and 15 days for car 10. Despite the long time in transit, the fruit from each car was in good condition for the auction. There were a few pears in car 11 that had begun to soften at the neck and were greenish yellow instead of yellowish green.

Discussion of results, Sacramento Valley shipments.

These tests with midseason and late shipments of Bartlett pears from the Sacramento Valley gave evidence that the safest procedure for such shipments was to precool them until they averaged 40° to 45°F. throughout the load and then ship them with two or more icings in transit. One reicing has been satisfactory when there was no delay in transit and the fruit was well precooled. When the weather was about normal, the fruit had temperatures of 70° to 75° when loaded, requiring 20 to 24 hours for precooling, but in warm weather 8 to 10 hours longer cooling may be called for. Methods of determining how much cooling has been accomplished are discussed in another part of the report.

These results are in agreement with those of 1941 in respect to the amount of precooling needed and the transit temperature desirable for early, midseason and late shipments of Bartlett pears. The amount of softening taking place in transit was considerably higher in 1942 than it was in 1941; about 40 percent of the test lots softened 3 pounds or more, whereas in 1941 only 13 percent softened this much. Early shipments having average transit temperatures of 57° and 56° in non-precooled or poorly precooled cars arrived too green in 1941 (tests 1, 3 and 5), whereas in 1942 (tests 1, 2 and 3) shipments having such temperatures and slightly higher ones arrived in excellent condition. Transit temperatures averaging 45° were a little too low for early shipments in each season.

Tests 12 and 13, Placerville, California, August 21. 744-box, solid loads, shipped initial ice only.

This test compared the behavior of pears precooled until they were 33°F. throughout the carload with that of other pears precooled to a much more easily attained temperature of 39°. The former fruit was precooled for 5 days in a precooling room and the latter was precooled for about 2 days. The temperatures in transit in the top layer doorway stack in these two cars are shown in figure 6. There was a difference of 4° in their average transit temperatures, the long cooled car having the lower temperature as was to be expected. The fruit in each shipment arrived in good condition, with more light green in evidence in the warmer car. No advantage was apparent from the longer cooling that the companion car received. The ice bunkers of both cars were 1/3 full upon arrival.

The effect of transit temperature on the development of breakdown during ripening.

In last season's tests no direct influence of transit temperature upon breakdown was observed. When the duplicate lots that were shipped under different temperatures were compared this season (table 3) it was evident that the fruit transported in the cooler car or in the cooler portion of the load had less breakdown than the companion fruit shipped under warmer temperatures. The small difference in breakdown found in the shipments from cars 12 and 13 where both temperatures were low was not significant, but in other tests it was. These records of breakdown are for fruit ripened at 83° F.; when duplicate lots were ripened at 67° breakdown was of no consequence.

The practical application from the results would appear to call for ripening California Bartlett pears at 65° to 70° to control breakdown and gain other benefits in flavor and appearance as well. This work demonstrated in both seasons that breakdown was an important factor whenever the pears were ripened at high temperatures, regardless of how well the shipment had been refrigerated.

The effect of transit temperatures on the flavor of pears when ripened.

Some of the test shipments had transit temperatures that differed considerably and a comparison of the flavor of these respective lots is made in table 3. When ripened at 67°, all lots were very similar in flavor irrespective of transit temperatures. When ripened at 83°, in most cases the fruit with the higher transit temperatures had the best flavor but this was not always true. In the 1941 tests, there was no apparent effect of transit temperatures on flavor.

Comparison of flavor in early, midseason and late shipments.

Last year there was a slight improvement in the flavor of pears from the same district as the season advanced, and this was also observed in 1942 (table 4).

RIPENING TEMPERATURE STUDIES

The influence of ripening temperature on breakdown.

Shipping tests

The results obtained in the ripening studies of 1942 agreed with those of the previous season in showing that breakdown could be eliminated almost entirely by ripening the pears at 65°F. to 70°F., whereas duplicate lots of fruit occasionally developed as much as 50 to 70 percent breakdown when they were ripened at 80° to 85°. The average amount of breakdown for all lots ripened at 67° was 0.3 percent, and for similar fruit ripened at 83° it was 36.5 percent (table 5). Every sample of fruit that was ripened at the higher temperature developed breakdown in 1942; in 1941 eight out of 54 lots did not. Breakdown was more severe in the test lots in the past season than in 1941, averaging 37 percent and 12 percent, respectively. These figures are for fruit ripened at 83°, the usual or prevailing temperature under which fruit ripens during warm weather in many markets. There was generally less trouble with breakdown on the retail market this year than in 1941 because the weather was cooler during much of the pear season. That pears had as great, if not greater, susceptibility to breakdown as in the previous season was shown by the ripening tests under controlled high temperatures.

Holding tests

After holding in storage at 42°F. for ten days, the fruit in one box of pears such as was used in the test shipments (tests 1, 2, 3, 4, 5, 8 and 9) was divided into two parts for ripening at 65° and at 83°F. In tests 1-4, inclusive, fruit was also ripened at 70-74° as was the case in 1941.

The holding tests, where only half a box of fruit comprised the sample, differed from the 1942 shipping tests in that only about half the samples ripened at 85° showed breakdown, and the amount averaged somewhat less than that in the test shipments, usually being 10 to 20 percent. This was probably due to better ventilation in ripening in half boxes as compared to full boxes used in the shipping tests. All fruit ripened at 85° did so imperfectly, being poorly colored and usually showing 25 to 50 percent scald when considered ripe. Rather than softening normally, the flesh was tough and spongy, and the dessert quality was invariably poor.

The results of the holding tests were in complete agreement with the shipping tests in that no breakdown or scald occurred at 65°, and all the fruit ripened with good appearance and good to excellent quality. Fruit ripened at about 70° was much less desirable.

Breakdown most prevalent in the center of the box.

At New York, records were kept of the location of breakdown in each of the boxes. To do this the fruits were separated into two groups, namely "outside" pears that were along the sides of the package and "inside" pears that were completely surrounded by other fruits. Usually there were about twice as many "outside" fruits

as "inside" fruits. In the 23 boxes ripened at 83°F., on which records were taken, an average of 54 percent of the inside fruit developed breakdown as compared with 30 percent of the outside fruit showing this trouble.

Usually the inside fruits felt warmer to the touch than those on the outside because of the heat given off by the ripening fruit. To ascertain the degree of overheating in the center of the packages, sensitive elements of recording thermometers were buried in the center of tightly packed boxes during the ripening period. Figure 11 presents the temperature records obtained during the ripening of the test boxes from car 11. These are typical of the records obtained in 8 other test boxes similarly handled. The pears were approximately 50° to 55° when placed in the ripening rooms and it usually required 3 to 4 days for those in the center of the boxes to warm to room temperature of 67°.

The fruit held at 83° warmed to 67° in the center of the box in 24 hours and to 83° in 48 hours and continued to rise in temperature to as high as 89° in some cases, maintaining such maximum for about a day. After the pears passed the firm ripe state their temperatures usually dropped a degree or two. These tests indicated that the fruit in the center of the boxes may become 4° to 6° higher than the air surrounding the package. The "heating" of the interior fruit in no way affected breakdown at 67° for practically none of the pears in any part of the boxes developed this disorder; but at 83° it was believed to be a factor contributing to the prevalence of breakdown in the center of the boxes. However, when samples of pears were ripened at a higher temperature of 88° under good ventilation they developed less breakdown than did similar fruit ripened at 83° with ventilation restricted to about the extent that occurs in the center of a packed box. Other workers have observed that Bosc pears from middle layers or in large boxes develop more core breakdown than does more exposed fruit and they ascribed this difference, in part, to the accumulation of toxic volatile substances. 1/

Fruit ripened as it might be done commercially.

A ripe Bartlett pear is so easily bruised that it cannot withstand the kind of handling usually given boxed fruit by truckmen on the market. Commercially, it would seem most satisfactory if the retailer ripened the fruit in his store. A few retail stores may be able to provide the necessary temperature conditions for this but the majority cannot. Therefore, the ripening must probably be done by jobbers or wholesalers who will keep the pears in the ripening rooms until they reach a firm-ripe stage and then truck them carefully to the retail outlet.

Three tests designed to show whether fruit ripened partially at 67°F. would complete its ripening satisfactorily when removed to an outside temperature of 83° were conducted. Packed boxes were not available for these tests. Instead, 40 to 50 fruits in paper bags were held at 67° until they reached a firm-ripe stage (pressure test about 6 pounds). Then they were moved to 83° to complete the ripening process. In no case did this fruit have as good flavor and color as that ripened continuously at 67°, but they were considerably superior to fruits ripened at 83°. The flavor was usually more nearly like that of fruit ripened at 67° than was the color.

The possibility of using banana ripening rooms for commercial ripening of the pears has been considered. Proper ripening temperatures for this fruit are identical with those for Bartlett pears. There was the question, however, whether

---

1/ Furlong, C.R. and Barker, J. - Report on ripening tests with So. African pears and plums. Bul. #23, So. African Coop. Deciduous Exchange., Ltd., 1935.

the gases given off by either kind of fruit might impair normal ripening of the other when held in the same room. To ascertain whether there was such an effect, green pears and green bananas were packed together loosely in uncovered jars and ripened at 67°F. In the two tests made, each kind of fruit ripened with excellent quality and showed no signs of abnormal ripening.

As mentioned earlier, practically no breakdown was seen in retail stores during the summer of 1942 and few complaints were heard of poor color and flavor. This was unlike the previous summer when breakdown was common and retailers complained frequently about the quality of the pears. The summer of 1942 was considerably cooler than the previous one. A continuous temperature record was kept in a large retail fruit store for the 6 hottest weeks of the summer. Only for a few periods of an hour or two did the temperature rise above 82°F., and most of the time it was in the low seventies.

Influence of ripening temperature on flavor.

The fruit ripened at 67° was better in flavor in every case than duplicate lots ripened at 83°, and the average flavor score of the former was 83 (in the excellent range) as compared to 55 (slightly above fair) for the higher ripening temperature (table 5). This difference in flavor, resulting from ripening temperature, was even greater than in the 1941 tests. The pears developed good aroma, juiciness, a melting consistency of the flesh, and an attractive bright yellow color at 67°, whereas those ripened at 83° were often insipid, dry, mealy or woody in texture, or failed to soften. Sometimes the pears ripened at the higher temperature had a disagreeable acid taste. Their color was usually pale yellow or greenish and not attractive bright yellow. This same general effect of high temperatures on dessert quality was obtained in ripening tests at Davis. All of the fruit ripened at 80° to 85°F. was very insipid and was rated poor.

Time required to ripen at high and low temperatures.

In some cases the pears ripened 2 days sooner at 67°F. than they did at 83°, in others there was no difference. The fruit ripened at the lower temperature also remained in a salable condition about a day longer than companion lots ripened at 83°.

In the holding tests at Davis where the effects of temperatures of 65° and 85° were compared, fruit at the lower temperature required on the average six days to ripen. Pears held at 85° ripened so imperfectly that the exact time of ripening was determined with difficulty. The average time recorded, however, was 10.5 days, with one lot requiring 14 days. All fruit ripened at 85° was of poor color and flavor, badly scalded and was considered unmarketable when ripe.

Discussion of ripening temperature results.

These results from two year's work show that the temperature at which Bartlett pears are ripened has a marked influence on their flavor and appearance and that ripening temperature is the solution to the problem of controlling a type of breakdown generally occurring on the retail markets during warm weather.

Although several investigators have shown that temperatures of 80°F. and higher cause off flavors and lack of flavor as well as retardation of softening and of color development, the relation between high-temperature ripening and development of breakdown has not been reported heretofore. These tests also indicated

that ripening at 65° gave slightly better flavor, texture and juiciness than at 70° or higher temperatures.

Comparison of breakdown in washed and unwashed pears.

Shipping tests

It has been contended by some shippers and growers that acid washing of pears predisposes them to breakdown. Shipping tests designed to answer this question were made in four cars. Fruit from the same orchard was divided into two lots, one of which was washed in hydrochloric acid of about 1.0 percent concentration by weight in a commercial washer and the other lot was not washed. Two boxes of washed and unwashed fruit were shipped from each lot to provide enough fruit for ripening at 67° and at 83°. A different method was used in test 9 when the washed and unwashed fruits were packed in the same box so that they would have identical transit temperatures. The treatment that the pears received was designated by number on the wrapper and the pears from each of the five treatments were distributed throughout the box.

The results are summarized in table 6. There was practically no breakdown in either the washed or the unwashed fruit when it was ripened at 67°, this temperature controlling it as in previous tests. When the fruit was ripened at 83°, the amount of breakdown was not consistently greater in the washed as compared with the unwashed. In test 5, it was greatest in the unwashed fruit of one lot and in the washed fruit of the other lot (washed in warm acid), More breakdown was found in the washed fruit in tests 7 and 9 than in the unwashed. In test 8 the unwashed fruit developed the most breakdown. The inconsistent results show that the different lots of fruit were extremely variable in their predisposition to breakdown, and that if the acid had any effect on this trouble it was covered up by the variability of the pears making up the sample. In the special packs of test 9 the pears were fairly well mixed; even here there was no indication that the acid-wash treatment caused breakdown. The fruit washed in warm acid, not rinsed, showed severe acid injury in the form of small brown spots on the surface, yet it had the least breakdown of all the fruit including the unwashed and the wiped lots.

Holding tests at Davis.

Washed and unwashed pears from the same lots as those shipped in tests 5, 8, 9 and one additional lot from Lake County were also held in storage at Davis for the transit period at 40°, and then were ripened at 65° and at 85°F. No breakdown occurred in any fruit ripened at 65° whether washed or unwashed, and out of a total of forty samples ripened at 85° only four showed breakdown. All of these were from the same orchard. The commercially washed fruit (1.0 percent HCl at 70°) developed 15 percent breakdown; the unwashed fruit, 10 percent. Additional samples of fruit washed experimentally in 2 to 4 percent HCl at 80° and at 90° showed 0, 10 and 10 percent breakdown for the different treatments.

Typical acid injury (small brown spots on the surface of the fruit) was not evident on any commercially washed pears or on fruit washed experimentally in 2 percent acid at 110°F. for 45 seconds. Slight acid injury was obtained from washing in 4 percent acid at 73° for one minute and also on fruit imperfectly rinsed which had been washed in 2 percent acid at 80° for 45 seconds. Severe acid injury, but no watery breakdown, occurred on fruit washed in 1 percent acid at 100° for 45 seconds where the rinse was omitted. These results emphasize (a) the necessity of thorough rinsing to avoid acid injury even with 1 percent acid, and (b) the absence

of any effect on the development of breakdown from washing in strong acid (2 to 4 percent) even when rinsing was not thorough.

Precooling studies.

Last year's tests showed that transit temperatures in standard cars were influenced more by precooling than by the frequency of reicings in transit or the application of salt to the ice. The efficacy of precooling in lowering transit temperatures was demonstrated again in 1942. The results of the two season's tests have been combined in figure 7 in which the average transit temperature (top layer, doorway stack) is compared with the temperature of the load when the car was shipped.

The time required to precool a carload of pears from initial temperatures in the range of 70° to 75° to final temperatures in the range of 30° to 55° is shown in figure 8, which is based on the precooling tests of 1941 and 1942 with various types of car precooling equipment and warehouse precooling. The precooling periods are those required to cool fruit in the center of the boxes to the temperatures shown. About 24 hours were needed to cool carloads of pears to a temperature of 40° to 45°. For lower precooling temperatures of 30° to 32°, as much as 60 to 100 hours were necessary. If the fruit was cooler than 70 to 75° at the start, the time would be shortened slightly, if warmer it would be lengthened accordingly. Cooling rates of 1 to 1.25 degrees per hour were obtained for ordinary jobs of cooling, whereas for fruit cooled to 33° and 39° the rates were 0.7 and 0.9 degrees per hour respectively (table 7). Those rates were about the same as those obtained last year.

About 10,000 pounds of ice was melted in average jobs where the pears were cooled from a starting temperature of about 70° to a final temperature of 44°. The two season's precooling tests indicated that a temperature reduction as high as 3.7 degrees per 1,000 pounds of ice melted was unusual and that in most cases it was in the range of 2.50 to 2.75 degrees.

The amount of salt used was in the range of 750 to 1,000 pounds applied in amounts of 125 to 250 pounds at a time to the ice in the bunkers. Under this method of handling the ice, an air blast averaging as low as 30° to 35° for the entire cooling period was the general rule. If less salt was used air temperatures would be higher and rates of temperature reduction would be lower than those mentioned.

Examples of ordinary and long cooling jobs with propeller fans and ice are shown in figures 9 and 10. About 24 hours were required to cool the pears to 45° in each of these tests, the middle layers having temperatures several degrees higher than the average of all positions and the top layers registering 2 or 3 degrees lower than the average. Four applications of salt of 250 pounds each and replenishing the bunkers with ice before the level became low resulted in desirable low air-blast temperatures in car 10 (figure 10).

The question of finding a single accessible position in the load, such as the top layer of the doorway stack where a temperature could be taken to estimate the cooling accomplished was investigated further in 1942. Sometimes the fruit here was close to the average of all nine positions used in the precooling tests; but at other times, depending on how the fans were tilted or on the method of loading, it was either cooler or warmer. Other means of estimating the amount of precooling accomplished, (such as the time the fans were run, the temperature of the air blast and the amount of ice melted) appears to be more feasible and more likely to be followed since much of this information is supplied by the precooler's reports. The fruit temperatures shown on such reports are for superficial locations and are

quite misleading if they are mistakenly believed to represent the temperature in the center of the boxes and in various parts of the load.

SUMMARY

Early shipments of Bartlett pears from California were benefited by transit temperatures high enough to allow some development of color as long as too much softening did not take place. Average temperatures of 54° and 56° were satisfactory but at 62° a few of the pears were too ripe on arrival. These temperatures were secured in three non-precooled shipments, the first two of which were shipped under standard refrigeration and the third with only two reicing in transit. Satisfactory results were likewise obtained by precooling the fruit for about 20 hours and shipping the car with two reicings. This would be a safer method than no precooling if the weather should turn warm.

For midseason and late shipments, precooling the fruit until it was 40° to 45° and shipment with two or more reicings gave good results.

Pears with cool transit temperatures developed less breakdown when ripened at 83° than did similar fruit from warm cars. This was not observed in 1941. In both seasons, ripening at 65° to 67° controlled breakdown, regardless of transit temperature. No effect of transit temperature on flavor of ripened fruit was noticed in either season.

Breakdown was controlled by ripening pears at 67° as it had been in the previous season. The fruit was more susceptible to this trouble in 1942 than in 1941, the comparative percentages of breakdown for the two seasons being 12 for 1941 and 37 for 1942 for those lots ripened at 83°. It was less prevalent on the retail markets in 1942 than in the previous season because the weather was cooler and therefore more favorable for ripening.

Fruit ripened at 65° to 67° developed good aroma, juiciness, a melting consistency of flesh and an attractive bright yellow color. The flavor was better than that of pears ripened at 80° to 85° to represent fruit stand temperatures during warm weather. The latter were usually insipid, dry, mealy, and woody in texture and they sometimes had an acid, disagreeable taste. The fruit usually ripened a little faster at the lower temperatures and had longer life after it was ripe than the lots ripened at 80° to 85°.

Breakdown was less prevalent among pears in the outside layers of the box than it was in fruit at the center where temperatures were often 4° to 6° higher during the ripening process. Lack of ventilation was probably the chief contributing factor, for pears developed more breakdown when ripened at 83° with poor ventilation than they did at temperatures 5 degrees higher with good ventilation.

Tests made to imitate commercial ripening of Bartlett pears indicated that quality and color could be improved over that obtained at 83° by ripening at 67° to the firm ripe state and completing ripening at 83°. Banana rooms provide ideal ripening temperatures and humidities for pears; when these two fruits were ripened together, each ripened normally and attained excellent quality.

There was no relation between the use of acid wash and breakdown. In some instances the washed fruit had more breakdown and in other shipments the reverse was true. Ripening at 65° to 67° controlled breakdown in both washed and unwashed lots.

Transit temperatures were controlled to a great extent by the amount of precooling the fruit received. About 24 hours were needed to cool a carload of pears with an initial temperature of 70° to 75° to a final average temperature of 40° to 45°. When precooled to this extent, the top layers usually had an average transit temperature of 45° to 50°. Such cooling proved to be low enough to deliver pears in good condition to the New York market. When fruit warmer than 70° to 75° is encountered, longer precooling will be called for.

The best criteria for estimating the cooling accomplished were the time the fruit was precooled, the temperature of the air blast, and the amount of ice melted.

ACKNOWLEDGMENTS

The agencies engaged in this work wish to express their appreciation to the shippers and growers whose wholehearted cooperation made the work possible, also to the committees which were helpful in outlining the problems and suggesting methods of attack, and to the precooling agencies, cold storage firms, refrigerator car companies and railroads for their assistance.

- - - - - - - - -

TABLE 1
LIST OF TEST SHIPMENTS, 1942

TEST NO.	CAR NUMBER	TRANSIT PERIOD	PRECOOLING RECORD		REFRIGERATION IN TRANSIT	SHIPPER	SHIPPING POINT	KIND OF LOAD
			TIME	FINAL TEMP. 1/				
	PFE		Hrs.	°F				
1	30569	7/15-27	None	--	Standard Refrigeration	American Frt. Growers	Walnut Gr.	720 through
2	70439	7/20-29	None	76	Rule 254, Reiced twice	DiGiorgio Frt. Corp.	Yuba City	--
3	45421	7/25-8/4	None	--	Standard Refrigeration	Stillwater Orchards	Courtland	550 braced
4	70089	7/26-8/6	21-1/2	44	Rule 254, Reiced twice	Calif. Frt. Exchange	Courtland	720 braced
5	91418	7/30-8/10	23-1/2	45	Std. Ref., 3% salt, 1st icing	Lambert Mktg. Co.	Locke	720 through
6	16698	7/29-8/10	18-1/2	44	Rule 254, Reiced twice	DiGiorgio Frt. Corp.	Yuba City	680 channel braced
7	23541	7/29-8/10	8	55	Rule 254, Reiced twice	DiGiorgio Frt. Corp	Yuba City	680 channel braced
8	41137	8/7-19	21	39	Standard Refrigeration	Stillwater Orchards	Courtland	720 braced
9	23312	8/8-19	None	--	Standard Refrigeration	Lambert Mktg. Co.	Placerville	--
10	94990	8/12-27	42	39	Rule 254, Reiced twice	DiGiorgio Frt. Corp.	Yuba City	608 braced
11	26164	8/12-27	14-1/3	51	Rule 254, Reiced twice	DiGiorgio Frt. Corp.	Yuba City	608 braced
12	60212	8/21-31	120	33	Rule 240, Initial Ice	Calif. Frt. Exchange	Placerville	744 through
13	60213	8/21-31	44	39	Rule 240, Initial Ice	Calif. Frt. Exchange	Placerville	744 through

---

1/ Average of 9 positions in load.

TABLE 2

SOFTENING OF BARTLETT PEARS DURING SHIPMENT AND THEIR CONDITION FOR THE AUCTION ON ARRIVAL AS INFLUENCED BY THE REFRIGERATION THEY RECEIVED

TEST CAR	TEST PERIOD	LOT	FIRMNESS 1/ WHEN PACKED	SOFTENED IN TRANSIT	CONDITION FOR AUCTION ON ARRIVAL	REFRIGERATION METHOD	AVE. 2/ TRANSIT TEMP.
			Lbs.	Lbs.			°F
				TOP LAYER, DOORWAY STACK			
1	7/15-27	1	21.0	14.0	Excellent, on ripe side	Non precooled, std. ref.	56
2	7/20-30	1	20.0	12.3	Excellent	Non precooled, reiced twice	62
3	7/25-8/4	1	19.5	2.5 3/	Slightly green	Non precooled, std. ref.	54
		2	20.4	0.6	Excellent	do	54
4	7/25-8/6	1	19.5	2.3	Excellent	Precooled to 44° reiced twice	49
		2	20.4	3.7	Excellent	do	49
5	7/30-8/10	1	19.0	8.6	Slightly ripe	Precooled to 45° std. ref. 3% salt first icing	50
		2	19.0	5.0	Excellent	do	50
		3	17.4	5.3	Slightly ripe	do	50
		4	17.4	9.6	Slightly ripe	do	50
6	7/29-8/10	1	20.7	0.4	Excellent	Precooled to 44° reiced twice.	50
7	7/29-8/10	1	20.9	5.2	Excellent, few ripe	Precooled to 55° reiced twice	54
		2	20.9	3.2	Excellent	do	54
8	8/7-19	1	18.1	2.3	--	Precooled to 39° std. ref.	42
		2	18.1	2.9	--	do	42
10	8/12-27	1	17.8	0.7	Satisfactory	Precooled to 39° reiced twice.	41
11	8/12-26	1	17.8	2.8	Excellent	Precooled to 51° reiced twice	52
12	8/21-31	1	20.8	0.3	Color variable mostly hard green	Precooled to 33° initial ice	38
13	8/21-31	1	21.0	2.5	More light green than Car 12	Precooled to 39° initial ice	42
				BOTTOM LAYER, BUNKER STACK			
2	7/20-30	1	20.0	0.3 3/	Slightly green	Non precooled, reiced twice	45
3	7/25-8/4	1	19.5	3.6 3/	Slightly green	Non precooled, std. ref.	45

1/ Pressure test

2/ Average of recording thermometer record from time loaded until unloaded.

3/ Increase

TABLE 3
THE EFFECT OF TRANSIT TEMPERATURES ON THE DEVELOPMENT OF BREAKDOWN DURING RIPENING AT 83°. 1/

LOT	TEST CAR	TRANSIT TEMPERATURES COMPARED Higher Temp. °F	 Lower Temp. °F		BREAKDOWN Higher Temp. Pct.	 Lower Temp. Pct.
1	2	62	45		42	35
1	3	54	45		48	36
2	3 & 4	54	49		73	40
1	3 & 4	54	49		48	20
1	10 & 11	52	41		55	30
1	12 & 13	42	38		16	15
				AVERAGE	44.6	29.3

1/ When the pears were ripened at more favorable temperatures, 66 to 67°, breakdown was of no consequence.

- - - - - - - - - -

TABLE 4
THE FLAVOR OF BARTLETT PEARS FROM EARLY, MIDSEASON, AND LATE SHIPMENTS FROM THE SACRAMENTO VALLEY, 1942

		AVERAGE FLAVOR SCORE OF TEST LOTS 1/ Ripened at 67°	 Ripened at 83°
Early -	July 15 to 20	80	51
Midseason -	July 25 to 30	81	57
Late -	August 7 to 12	84	58

1/ Flavor Score:
0-24 - Poor
25-49 - Fair
50-74 - Good
75-100 - Excellent

TABLE 5
THE EFFECT OF RIPENING TEMPERATURE ON BREAKDOWN, FLAVOR, TIME TO RIPEN AND MARKET LIFE AFTER RIPENED

TEST CAR	LOT	BREAKDOWN 67°	BREAKDOWN 83°	1/ FLAVOR SCORE 67°	1/ FLAVOR SCORE 83°	RIPENING PERIOD 67°	RIPENING PERIOD 83°	DAYS SALABLE AFTER RIPE 67°	DAYS SALABLE AFTER RIPE 83°
		Pct.	Pct.			Days	Days		
1	1	0.6	22.0	79	49	3	3	4	2
2	1	0.0	42.0	82	45	3	3	4	4
	1B 2/	3.0	35.0	78	60	6	7	6	6
3	1	0.0	47.7	80	60	4	5	5	5
	1B	0.0	36.0	81	45	6	8	3	1
	2	1.0	73.1	85	65	4	5	4	4
4	1	0.0	20.0	81	61	4	5	6	4
	2	0.0	40.0	86	55	4	6	5	2
5	1	0.0	36.0	80	60	4	4	3	2
	1X 3/	0.0	54.0	81	66	4	5	2	1
	2	0.0	40.0	80	58	4	4	1	2
	2X	0.0	16.0	86	54	3	3	3	3
6	1	0.0	57.0	71	45	5	7	2	0
7	1	1.0	63.0	81	60	5	5	1	2
	2X	0.0	52.0	78	50	5	5	0	2
8	1	0.0	17.0	81	50	5	5	3	4
	2X	1.0	21.0	86	50	5	5	4	3
9	1	0.0	31.0	92	52	4	4	3	1
	2X	0.0	20.0	92	51	3	4	4	2
10	1	0.0	30.0	85	62	5	6	5	4
11	1	0.5	55.0	85	70	5	5	2	2
12	1	0.0	15.0	88	52	5	7	4	1
13	1	0.0	16.0	83	57	5	7	4	1
Average		0.3	36.5	83	55	4.4	5.1	3.4	2.5

1/ Flavor Score: 0-24 Poor; 25-49 Fair; 50-74 Good; 75-100 Excellent.

2/ "B" Indicates this lot was shipped in the bottom layer, bunker stack; all these lots were shipped in the top layer, doorway stack.

3/ "X" indicates unwashed fruit, all other lots were acid washed.

TABLE 6
COMPARISON OF WASHED AND UNWASHED LOTS OF BARTLETT PEARS IN RESPECT TO BREAKDOWN WHEN RIPENED

TEST LOT	BREAKDOWN[1] Ripened at 67°	 Ripened at 83°
	Percent	Percent
Test 5, Locke, July 30, 1942		
Lot 1 - unwashed	0	54
Lot 1 - washed in unheated acid, 71°, 1% concentration.	0	36
Lot 2 - unwashed	0	16
Lot 2 - washed in warm acid, 100°, 1% concentration	0	40
Test 7, Yuba City, July 29, 1942		
Unwashed	0	52
Washed in unheated acid, 0.8% concentration	1	63
Test 8, Hood, August 7, 1942		
Unwashed	0	21
Washed in unheated acid, 65°F., 0.68% concentration	0	17
Test 9, Placerville, August 8, 1942		
Unwashed	0	20
Washed in unheated acid, 65-70°, 1% concentration	0	31
Special Pack, 5 lots per box		
Lot 1 - unwashed	0	12
Lot 2 - not washed, hand wiped	0	18
Lot 3 - washed in 1% HCl - 70°F.	1	18
Lot 4 - washed in 1% HCl - 100°F.	0	9
Lot 5 - washed in 1% HCl - 100°F. not rinsed.	0	3

---

[1] None of the fruit showed breakdown upon arrival.

TABLE 7
SUMMARY OF PRECOOLING TESTS ON BARTLETT PEARS
1942 SEASON

TEST	FRUIT TEMP. AVE. 9 POSITIONS		TEMPERATURE DROP		COOLING PERIOD	SALT USED & ICE MELTED DURING COOLING		TEMP. DROP PER 1M LBS ICE MELTED	AVE. AIR BLAST TEMP.	PRECOOLING EQUIPMENT
	Start °F	Finish °F	Total °F	Per Hr. °F	Hrs.	Salt Lbs.	Ice Lbs.	°F	°F	
4	71	44	27	1.25	21½	750	9800	2.75	35	2 Phillips ½ h.p. fans
5	68	45	23	1.00	23½	750	--	--	30	do
7	74	55	19	2.40	8	250	5300	3.40	39	2 Utility ½ h.p. fans
8	61	39	22	0.76	28	742	--	--	34	2 Phillips ¼ h.p. fans
10	72	33	39	0.93	41½	875	--	--	32	2 Utility ½ h.p. fans

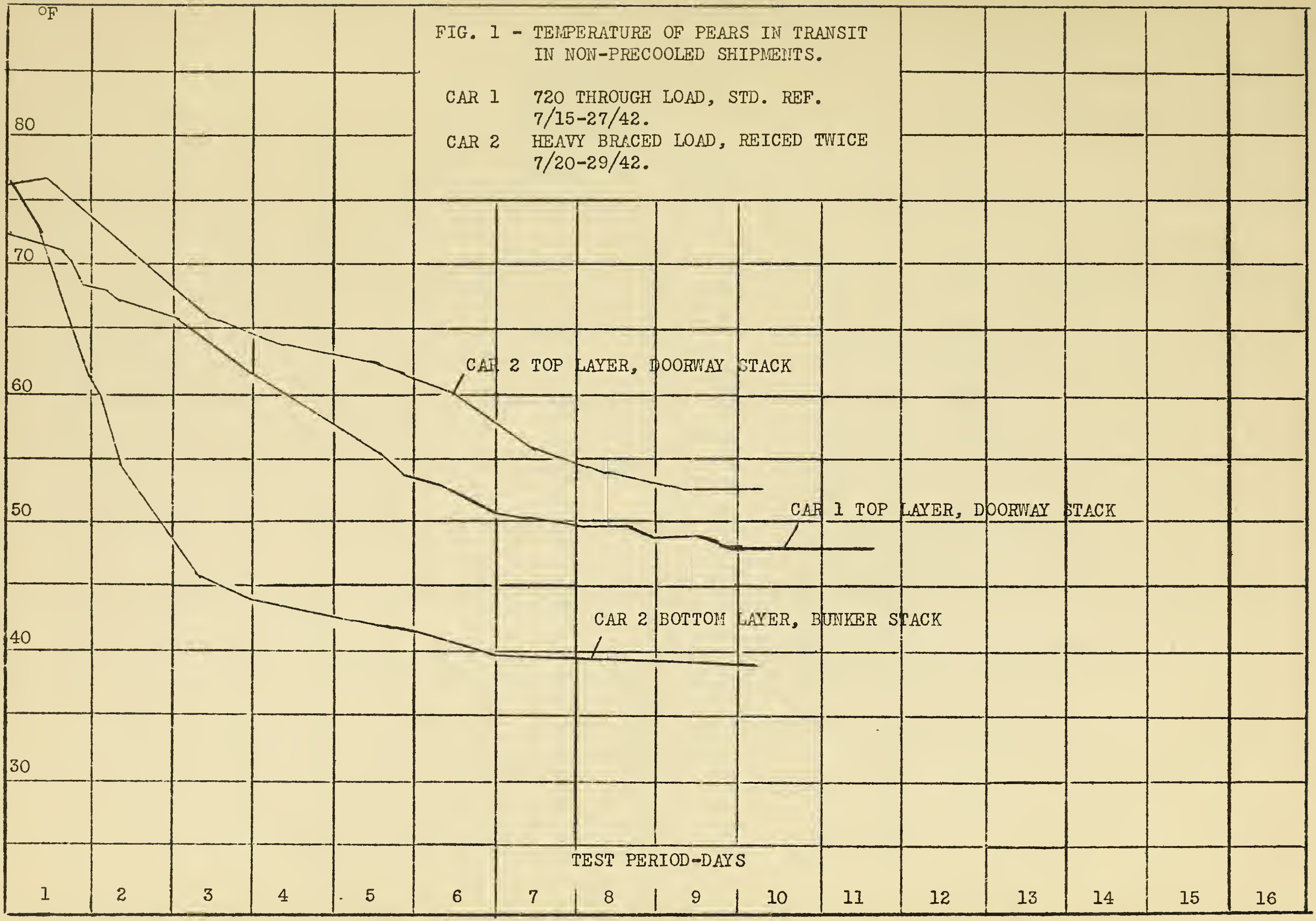


FIG. 1 - TEMPERATURE OF PEARS IN TRANSIT IN NON-PRECOOLED SHIPMENTS.

CAR 1 720 THROUGH LOAD, STD. REF. 7/15-27/42.

CAR 2 HEAVY BRACED LOAD, REICED TWICE 7/20-29/42.

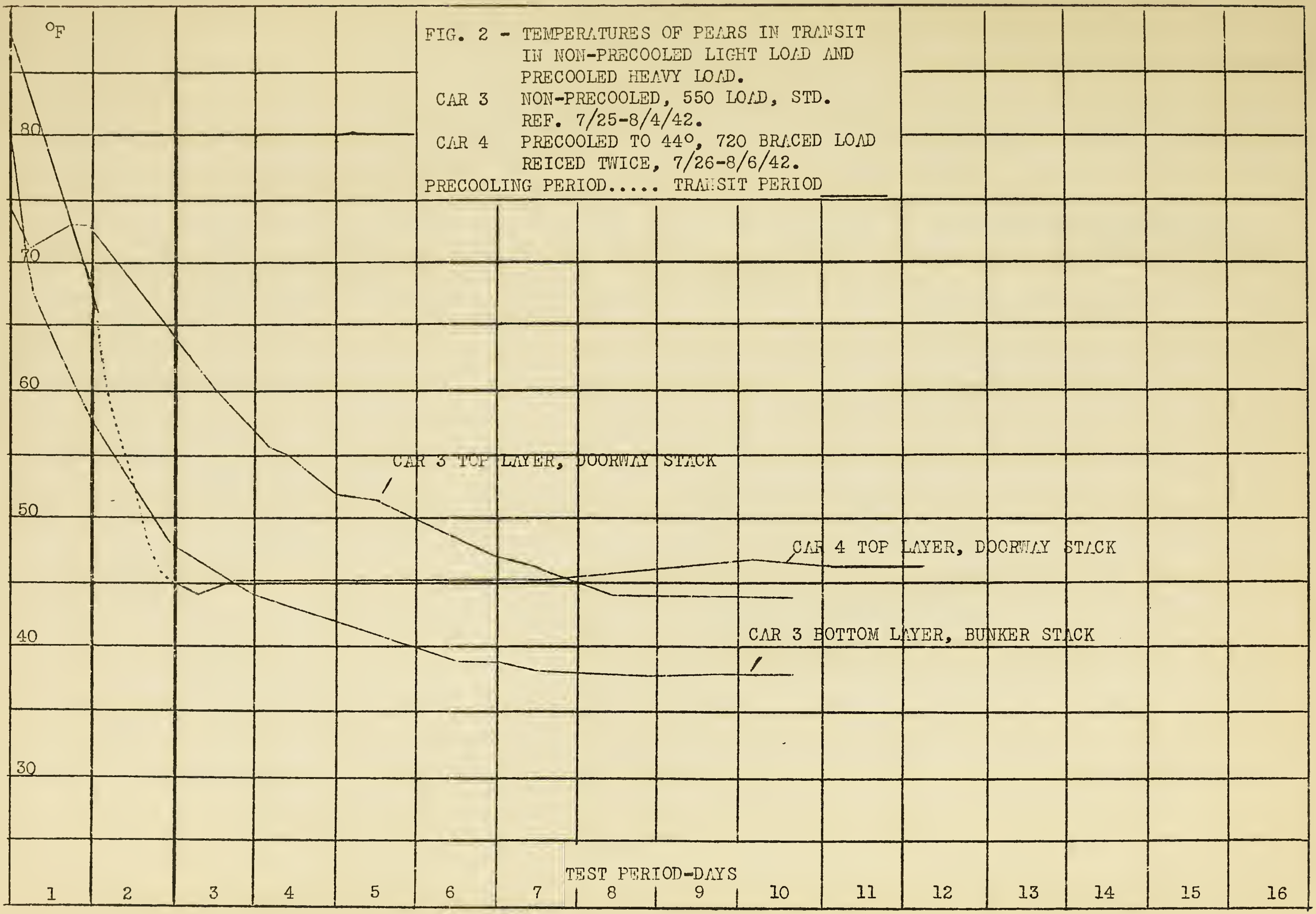


FIG. 2 - TEMPERATURES OF PEARS IN TRANSIT IN NON-PRECOOLED LIGHT LOAD AND PRECOOLED HEAVY LOAD.

CAR 3 NON-PRECOOLED, 550 LOAD, STD. REF. 7/25-8/4/42.

CAR 4 PRECOOLED TO 44°, 720 BRACED LOAD REICED TWICE, 7/26-8/6/42.

PRECOOLING PERIOD..... TRANSIT PERIOD ——

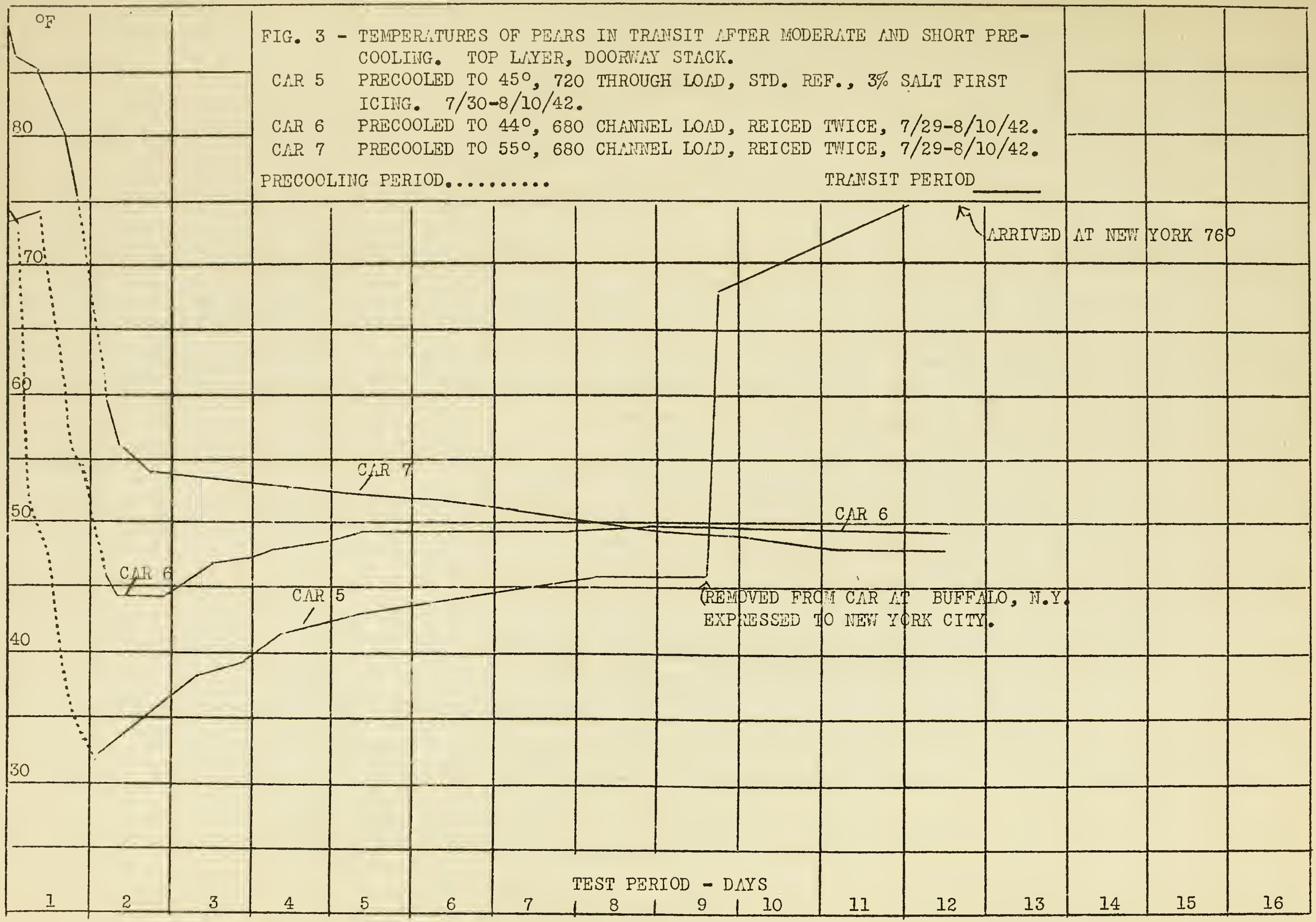


FIG. 3 - TEMPERATURES OF PEARS IN TRANSIT AFTER MODERATE AND SHORT PRE-COOLING. TOP LAYER, DOORWAY STACK.

CAR 5 PRECOOLED TO 45°, 720 THROUGH LOAD, STD. REF., 3% SALT FIRST ICING. 7/30-8/10/42.

CAR 6 PRECOOLED TO 44°, 680 CHANNEL LOAD, REICED TWICE, 7/29-8/10/42.

CAR 7 PRECOOLED TO 55°, 680 CHANNEL LOAD, REICED TWICE, 7/29-8/10/42.

PRECOOLING PERIOD.......... TRANSIT PERIOD ____

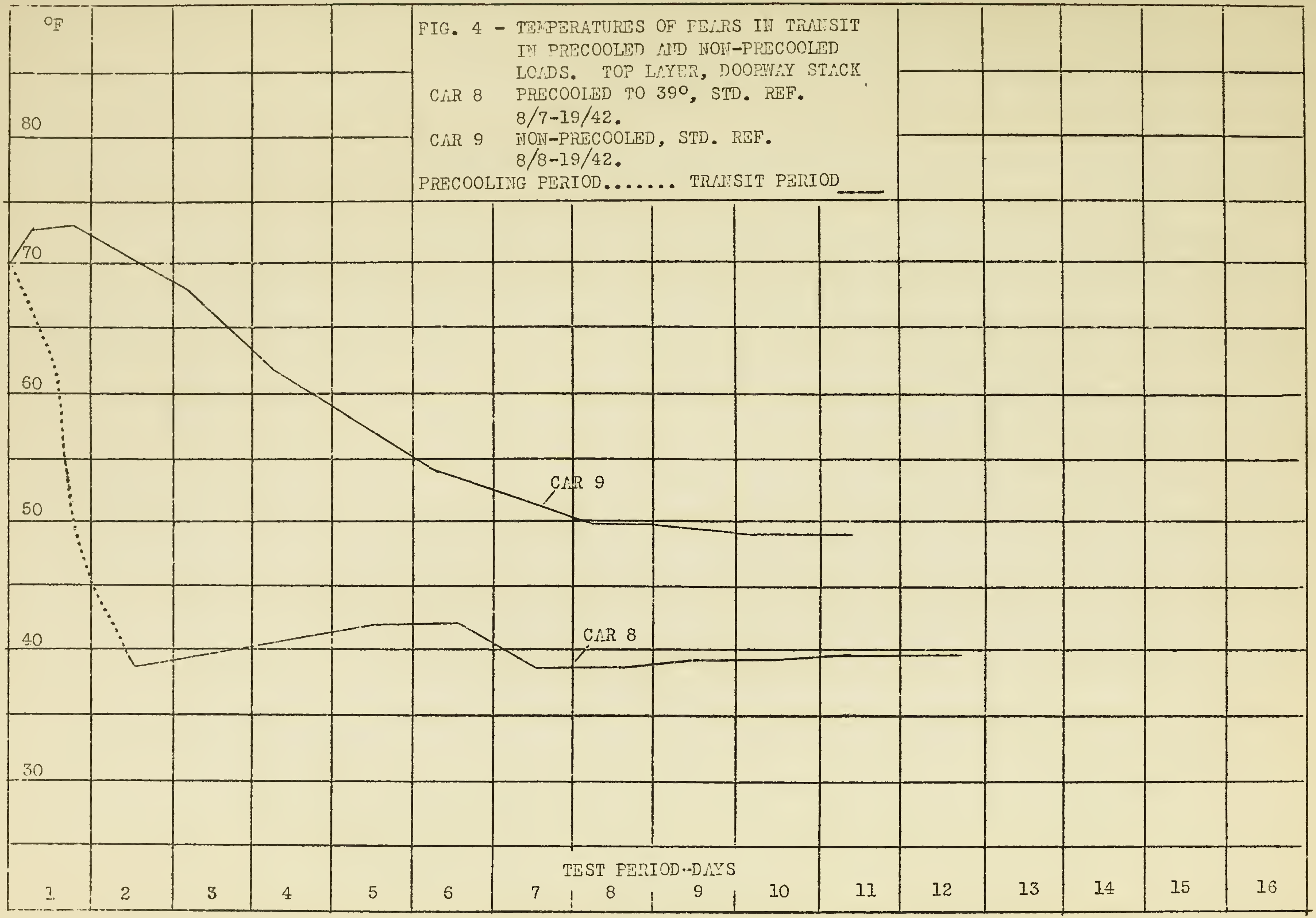


FIG. 4 - TEMPERATURES OF PEARS IN TRANSIT IN PRECOOLED AND NON-PRECOOLED LOADS. TOP LAYER, DOORWAY STACK

CAR 8 PRECOOLED TO 39°, STD. REF. 8/7-19/42.

CAR 9 NON-PRECOOLED, STD. REF. 8/8-19/42.

PRECOOLING PERIOD....... TRANSIT PERIOD ___

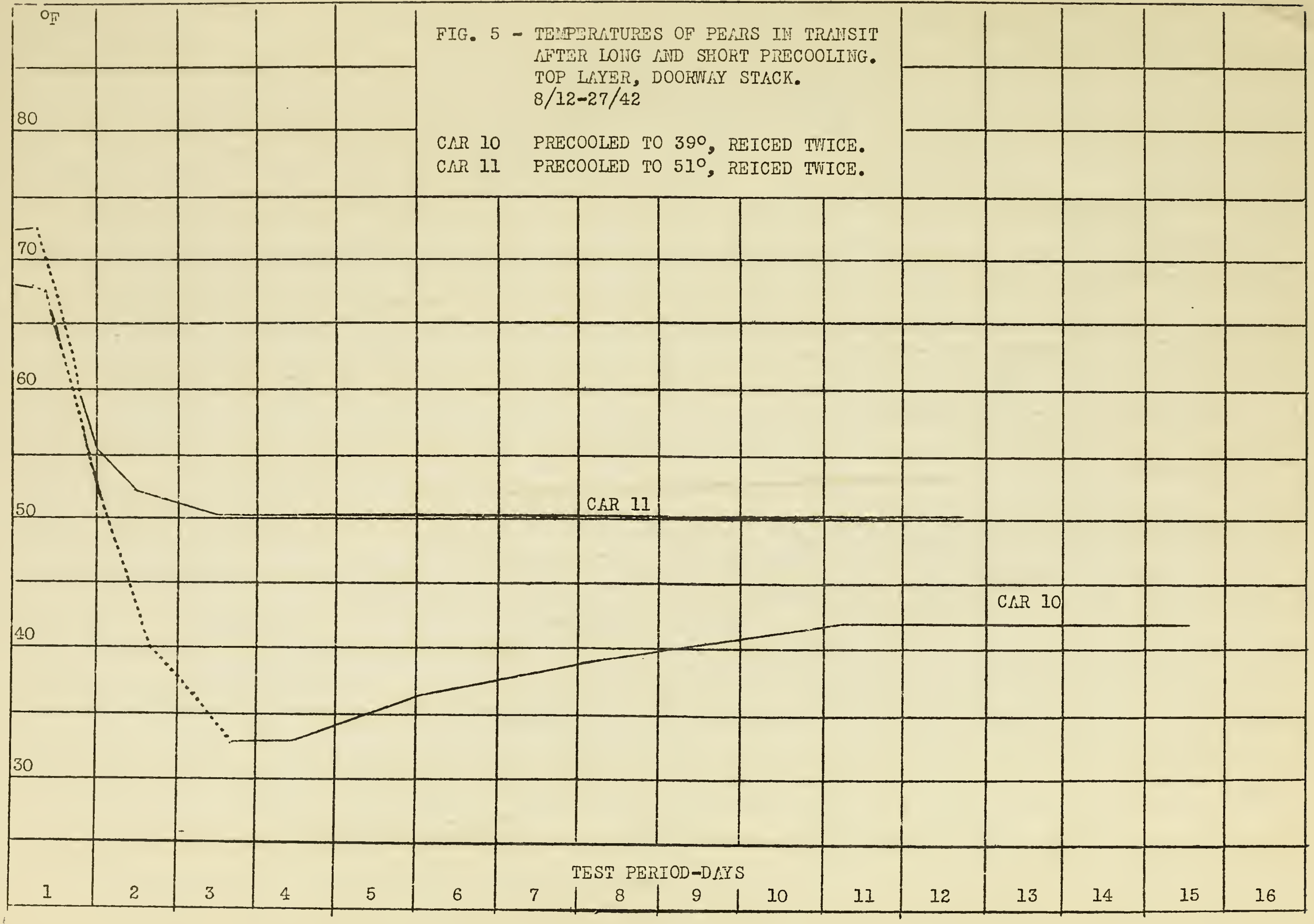


FIG. 5 - TEMPERATURES OF PEARS IN TRANSIT AFTER LONG AND SHORT PRECOOLING. TOP LAYER, DOORWAY STACK. 8/12-27/42

CAR 10 PRECOOLED TO 39°, REICED TWICE.
CAR 11 PRECOOLED TO 51°, REICED TWICE.

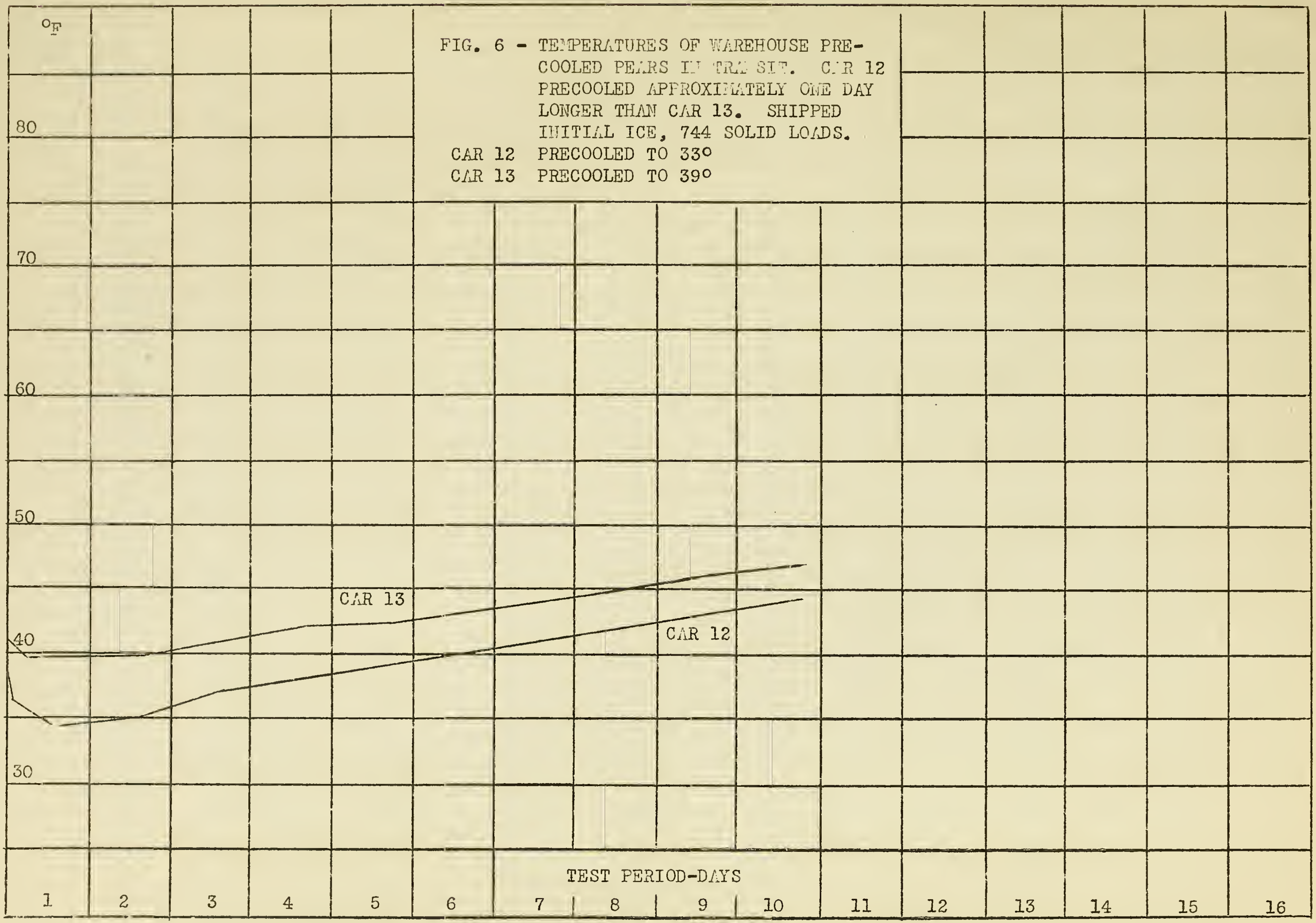
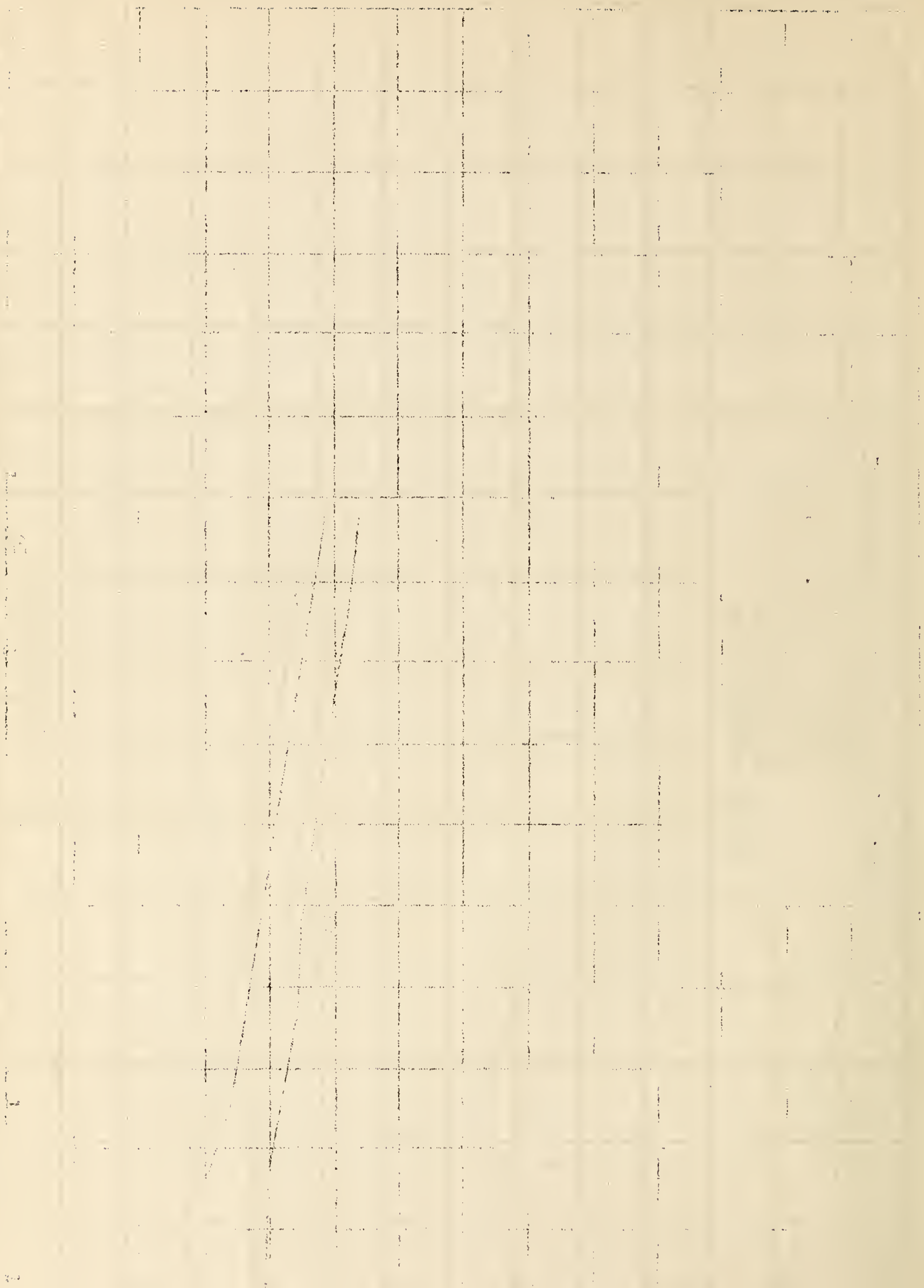


FIG. 6 - TEMPERATURES OF WAREHOUSE PRECOOLED PEARS IN TRANSIT. CAR 12 PRECOOLED APPROXIMATELY ONE DAY LONGER THAN CAR 13. SHIPPED INITIAL ICE, 744 SOLID LOADS.
CAR 12 PRECOOLED TO 33°
CAR 13 PRECOOLED TO 39°



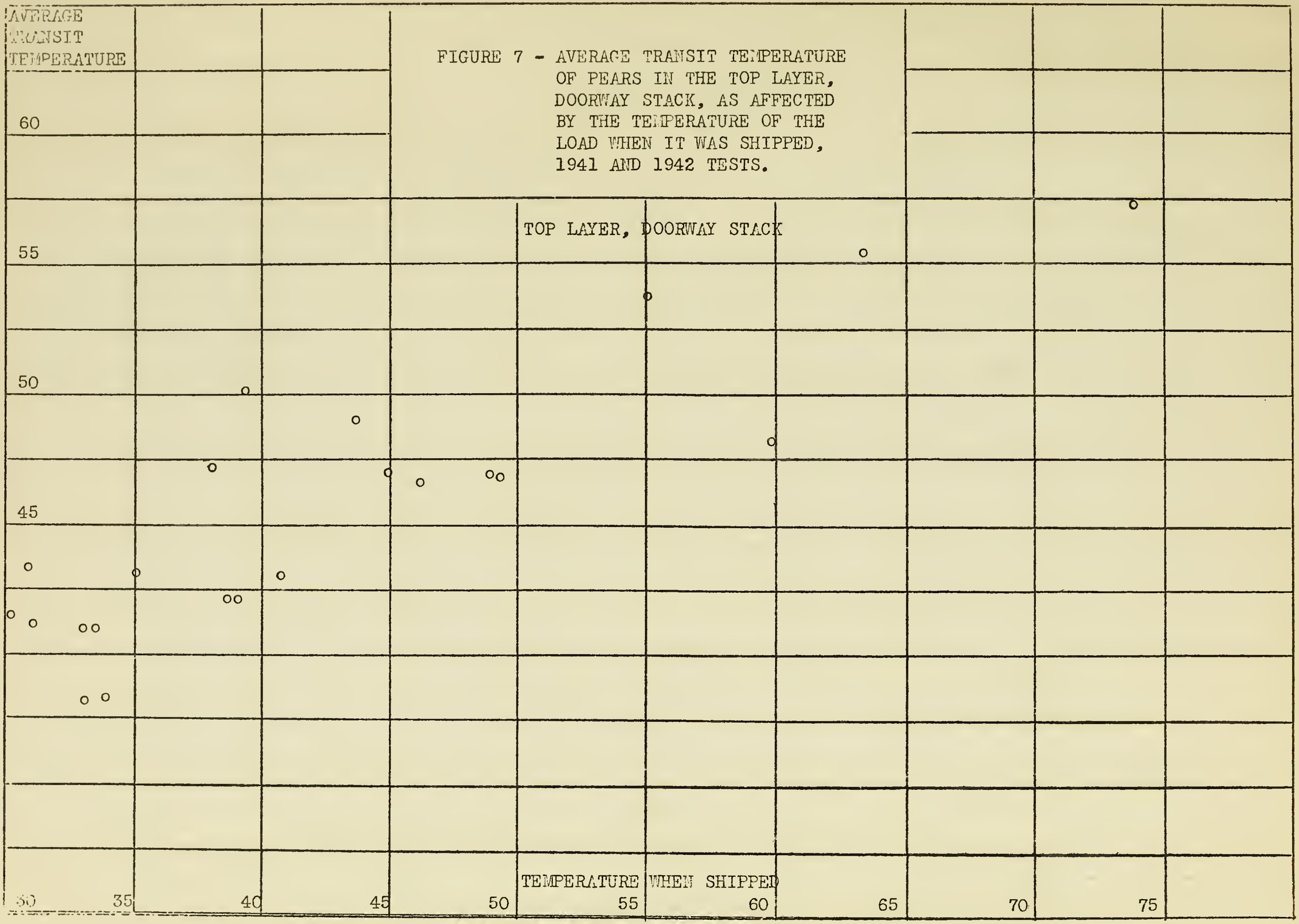


FIGURE 7 - AVERAGE TRANSIT TEMPERATURE OF PEARS IN THE TOP LAYER, DOORWAY STACK, AS AFFECTED BY THE TEMPERATURE OF THE LOAD WHEN IT WAS SHIPPED, 1941 AND 1942 TESTS.

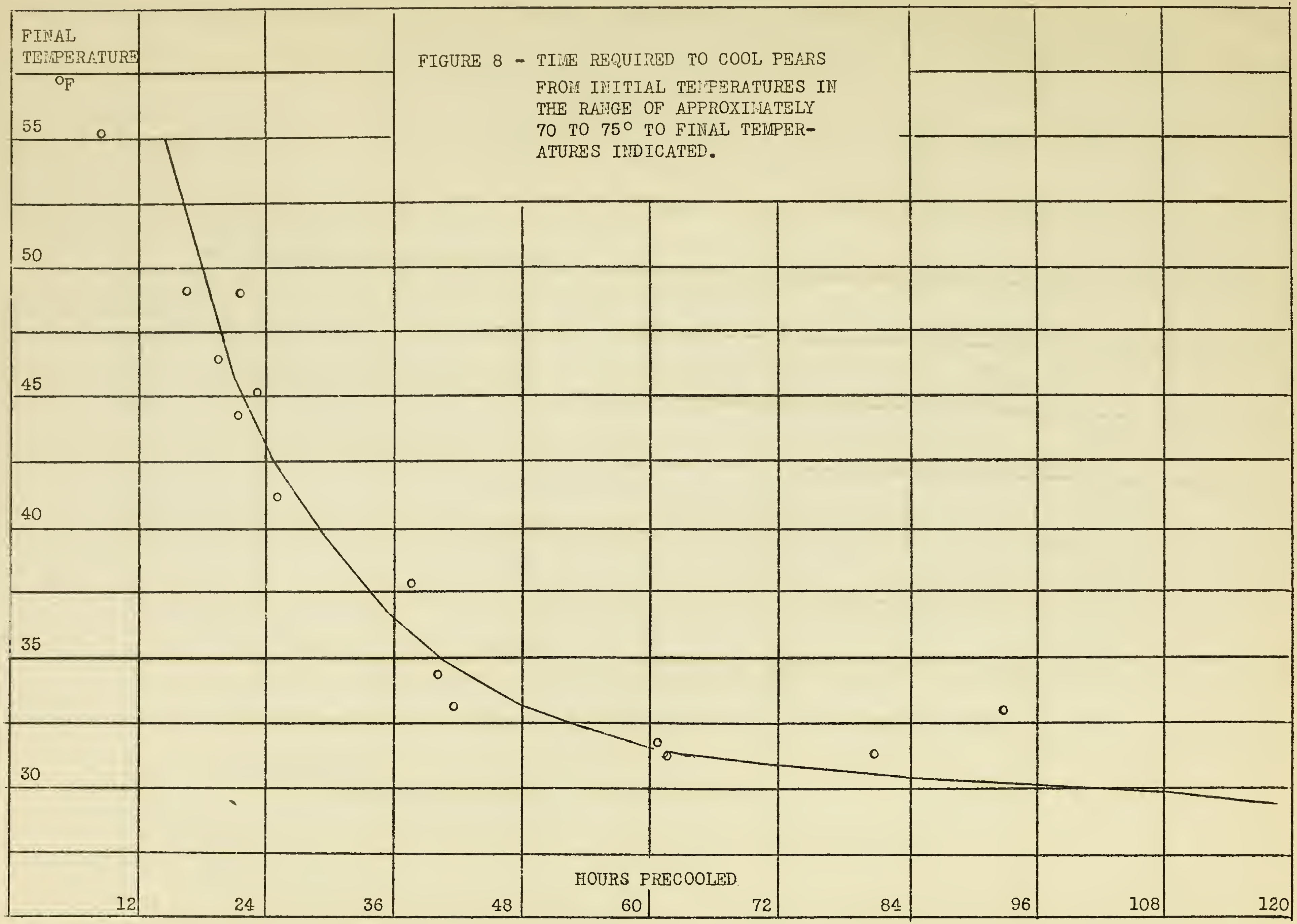
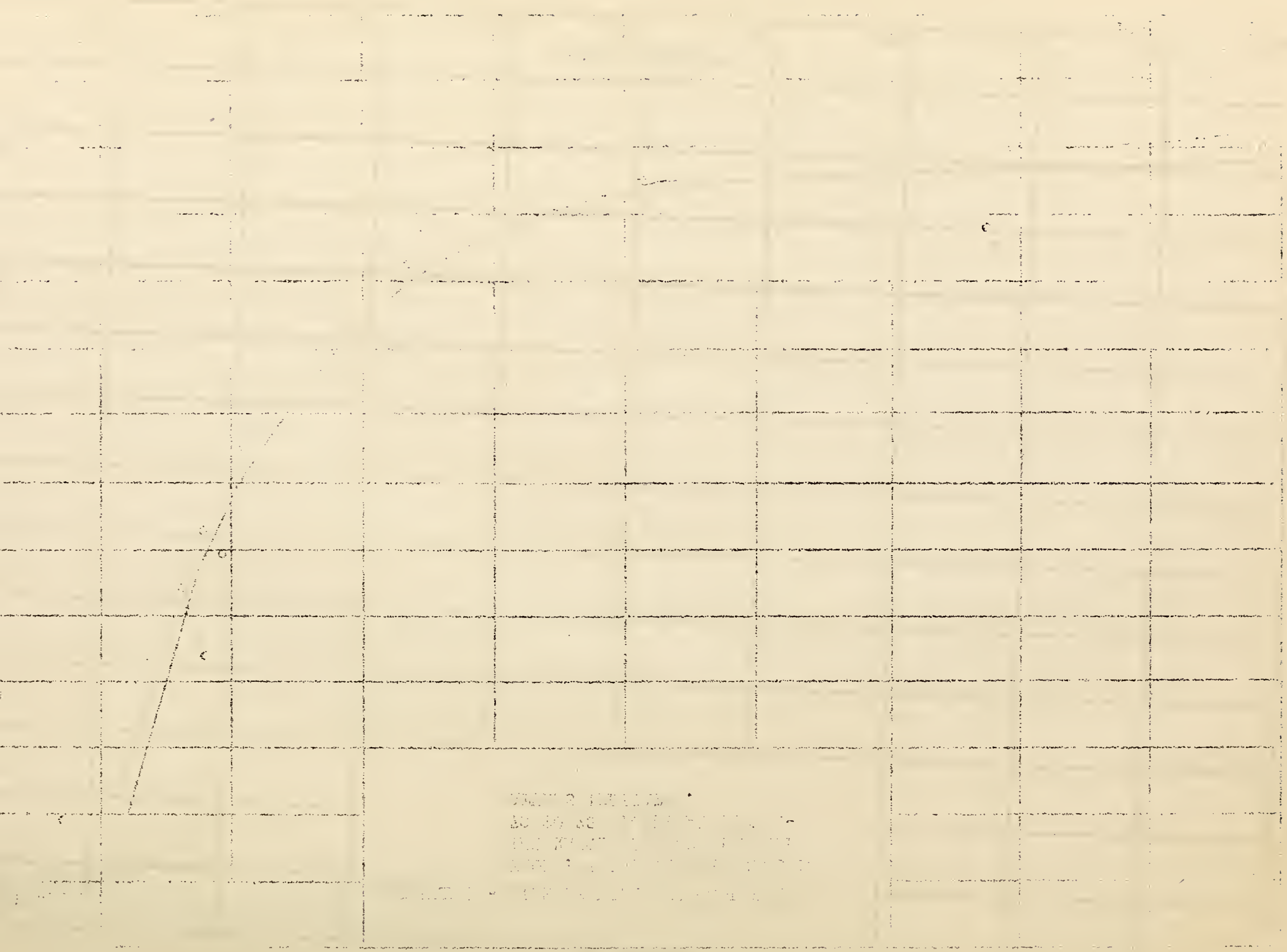


FIGURE 8 - TIME REQUIRED TO COOL PEARS FROM INITIAL TEMPERATURES IN THE RANGE OF APPROXIMATELY 70 TO 75° TO FINAL TEMPERATURES INDICATED.



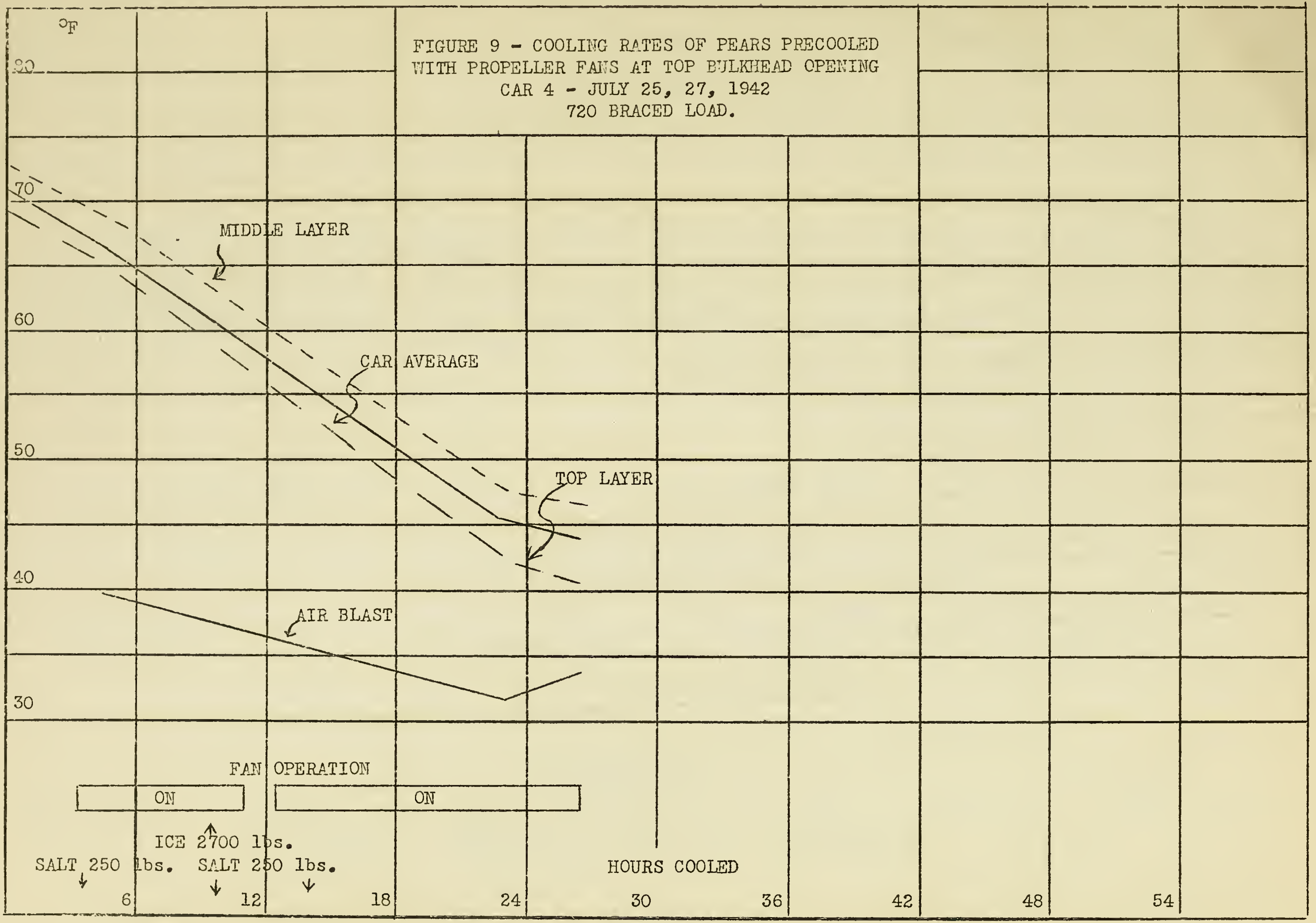
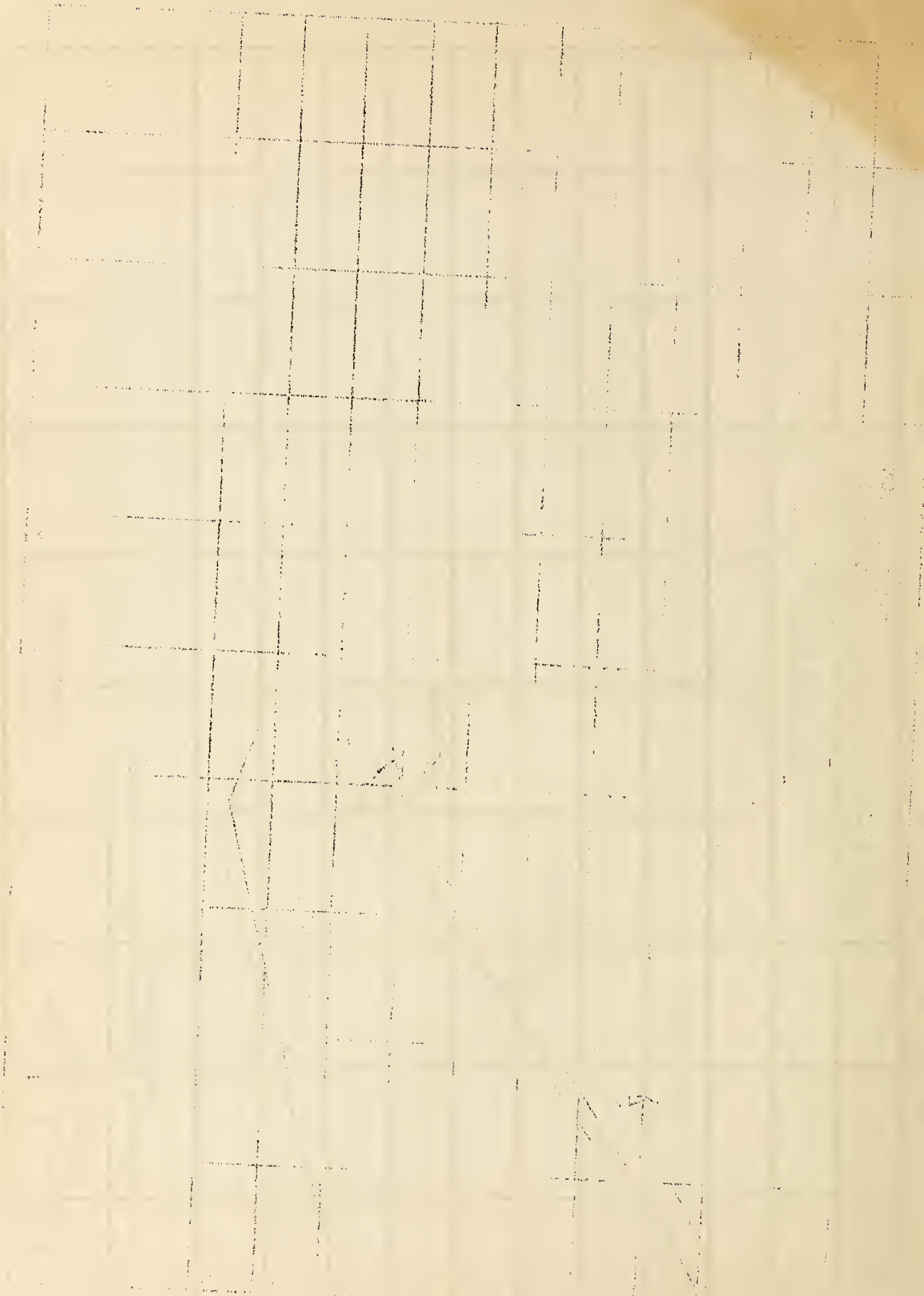


FIGURE 9 - COOLING RATES OF PEARS PRECOOLED WITH PROPELLER FANS AT TOP BULKHEAD OPENING
CAR 4 - JULY 25, 27, 1942
720 BRACED LOAD.



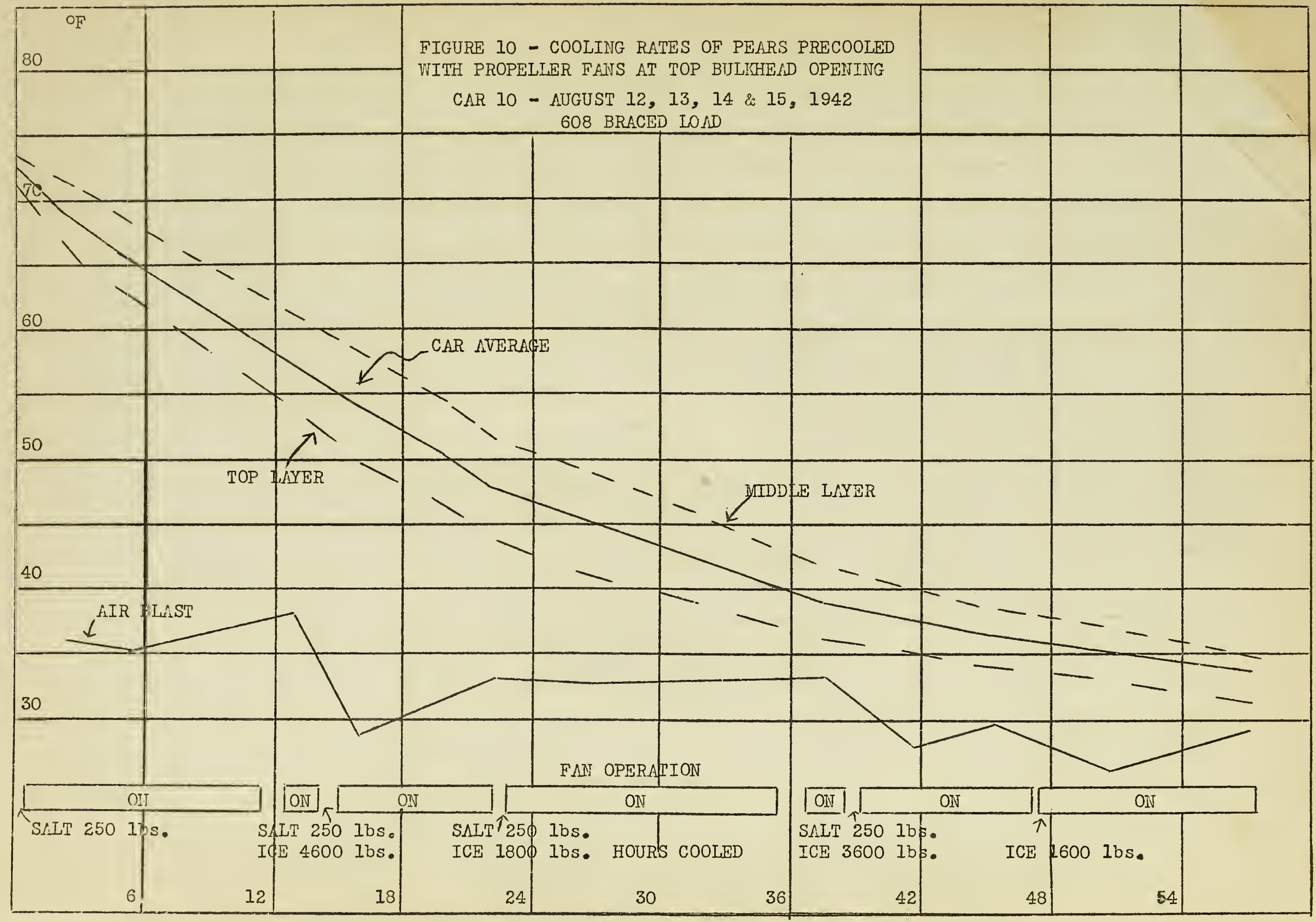


FIGURE 10 - COOLING RATES OF PEARS PRECOOLED WITH PROPELLER FANS AT TOP BULKHEAD OPENING

CAR 10 - AUGUST 12, 13, 14 & 15, 1942

608 BRACED LOAD